MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2017/2018

EMG2016 – ELECTROMAGNETIC THEORY

(BE, RE, TE)

12 OCTOBER 2017
2.30 p.m – 4.30 p.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 8 pages excluding cover page with 4 questions only.

2. Attempt ALL 4 questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the answer booklet provided.

4. Please tear off and attach your completed Smith Chart in the answer booklet.

QUESTION 1

a) Briefly define and explain the following terms related to transmission line theory:

i) Characteristic Impedance

ii) Lossless Transmission Line

iii) Distortionless Transmission Line

iv) Voltage Reflection Coefficient

[6 Marks]

b) The lumped-element model can be applied as the equivalent circuit of the transmission line. Use KVL and KCL to develop transmission line equations in time domain form.

[6 Marks]

c) Consider two antennas, each of input impedance $Z_{ant} = (73 + j0)\ \Omega$, are fed with lossless lines from a generator, as shown in Fig. Q1. R_C and R'_C are the characteristic resistance of the lines. Find

i) The input impedance (Z'_{in}) of the antenna-terminated line at the parallel juncture.

[4 marks]

ii) The input impedance (Z_{in}) of the feed line, and

[4 marks]

iii) The time-average power delivered to either antenna.

[5 marks]

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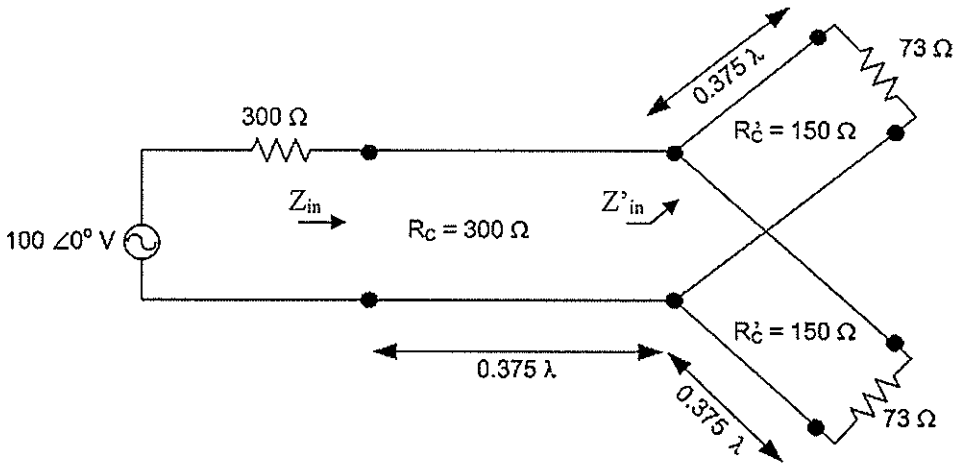

Fig. Q1

QUESTION 2

a) What do you mean by dominant mode? Determine the dimension of the air-filled rectangular waveguide, when the cut-off frequency of a TE_{10} mode is 6 GHz, where as that of TE_{01} mode is 14 GHz.

[7 marks]

b) Determine the dimension of the cubical cavity which operates at a resonant frequency of 4 GHz, when excited at the TE_{101} mode.

[5 marks]

c) A rectangular waveguide with dimensions $a = 2.5$ cm and $b = 1$ cm is to operate at 15 GHz. Given that the waveguide is filled with a medium characterized by conductivity $\sigma = 0$, relative permittivity $\varepsilon_r = 4$, and relative permeability $\mu_r = 1$, calculate the cutoff frequency, phase constant, phase velocity, and wave impedance for TE_{10} mode.

[13 marks]

Continued...

QUESTION 3

a) Name and describe the fundamental law related to the Maxwell equation below.

$$\nabla \times \mathbf{E} = -\partial \mathbf{B}/\partial t$$

[4 marks]

b) The square loop shown in Fig. Q3 is coplanar with a long, straight wire carrying a current $I(t) = 5\cos(2\pi \times 10^4 t)$ A.

(i) Determine the emf induced across a small gap created in the loop.

Hint: Assume the magnetic field due to the wire is $B = -\hat{x}\frac{\mu_0 I}{2\pi y}$

[9 marks]

(ii) Determine the direction and magnitude of the current that would flow through a 4-Ω resistor connected across the gap. The loop has an internal resistance of 1 Ω.

[3+3 marks]

(iii) If the current is replaced with $I(t)$= 5 A, determine the emf induced in part i). Explain your answer. [3 marks]

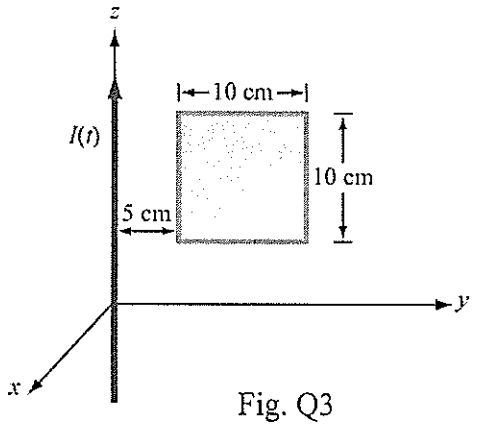

Fig. Q3

c) The plates of a parallel-plate capacitor have areas of 10 cm^2 each and are separated by 1 cm. The capacitor is filled with a dielectric material with $\varepsilon = 4\varepsilon_0$, and the voltage across it is given by $V(t) = 30\cos(2\pi \times 10^6 t)$ V. Find the displacement current.

[3 marks]

Hint: Displacement current density, $J_d = \frac{\varepsilon}{d} \cdot \frac{\partial V}{\partial t}$

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QUESTION 4

a) Given an electric field $\mathbf{E} = \hat{y}\ 25 \cos(\omega t + \beta x)$, propagating in a medium with $\varepsilon_r = 9$, $\mu_r = 4$, find the following:

i) Electric field in phasor form, $\tilde{E}$

[2 marks]

ii) The corresponding magnetic field, **H** in time domain

[5 marks]

iii) Magnetic field in phasor form, $\tilde{H}$

[2 marks]

iv) The Poynting vector, **S**

[3 marks]

v) The Average Power Density, $\mathbf{S}_{av}$

[2 marks]

b) An electromagnetic wave propagating in free space is incident normally on a lossless, nonmagnetic dielectric medium of $\varepsilon_r = 3$. find the following:

i) Reflection coefficient, Γ

[4 marks]

ii) Transmission coefficient, τ

[2 marks]

c) Explain the term skin-depth, δ. What is the skin-depth of a perfect dielectric and a perfect conductor?

[3+1+1 marks]

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Appendix : Physical constants

Constant	Symbol	Value
Speed of light in vacuum	c	$3x10^{8}$ m/s
Permittivity of free space	ε_o	$8.8542x10^{-12}$ F/m
Permeability of free space	μ_o	$1.2567x10^{-6}$ N/A^2
Intrinsic impedance of free space	η_o	377Ω

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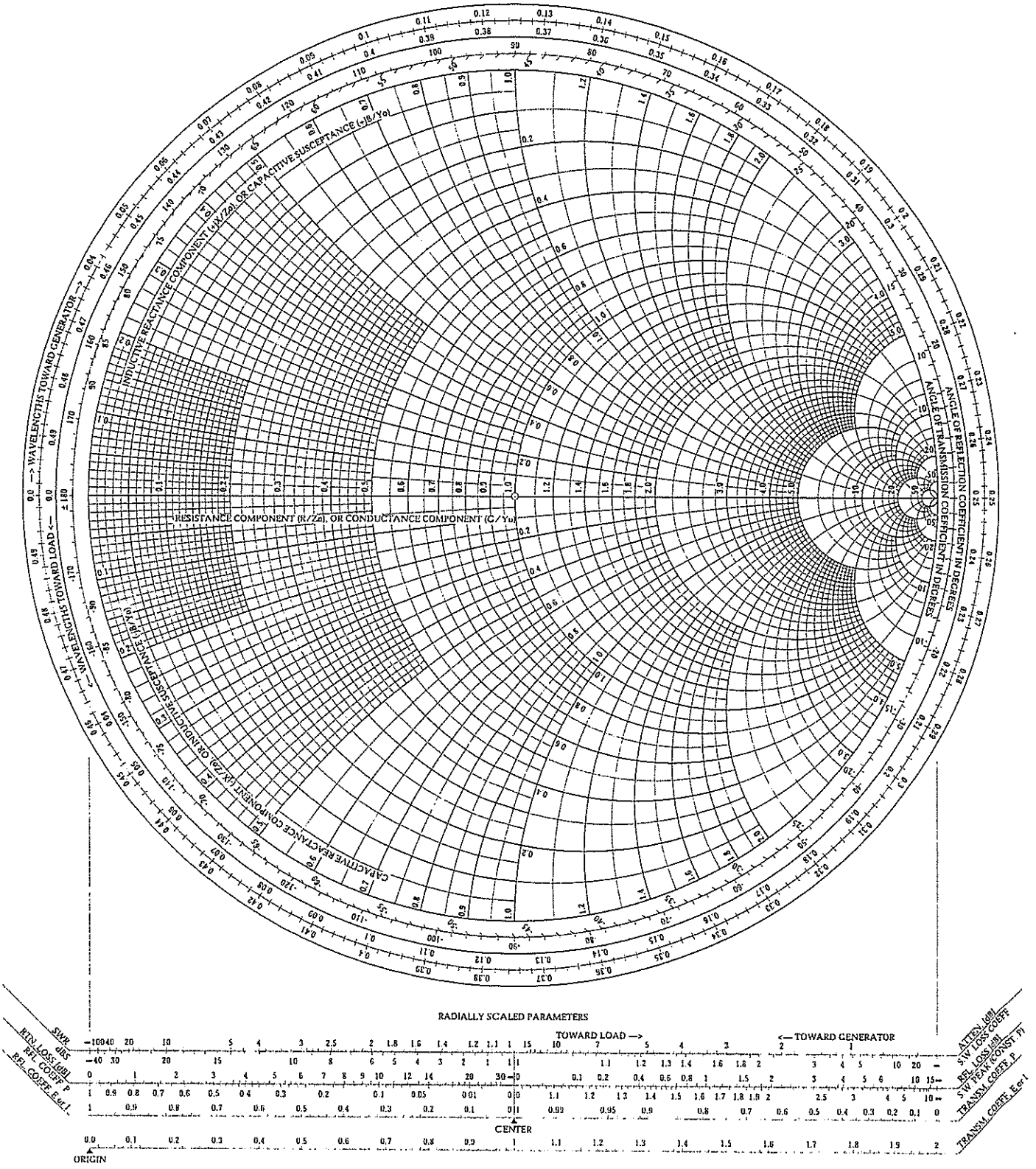
The Complete Smith Chart

Black Magic Design



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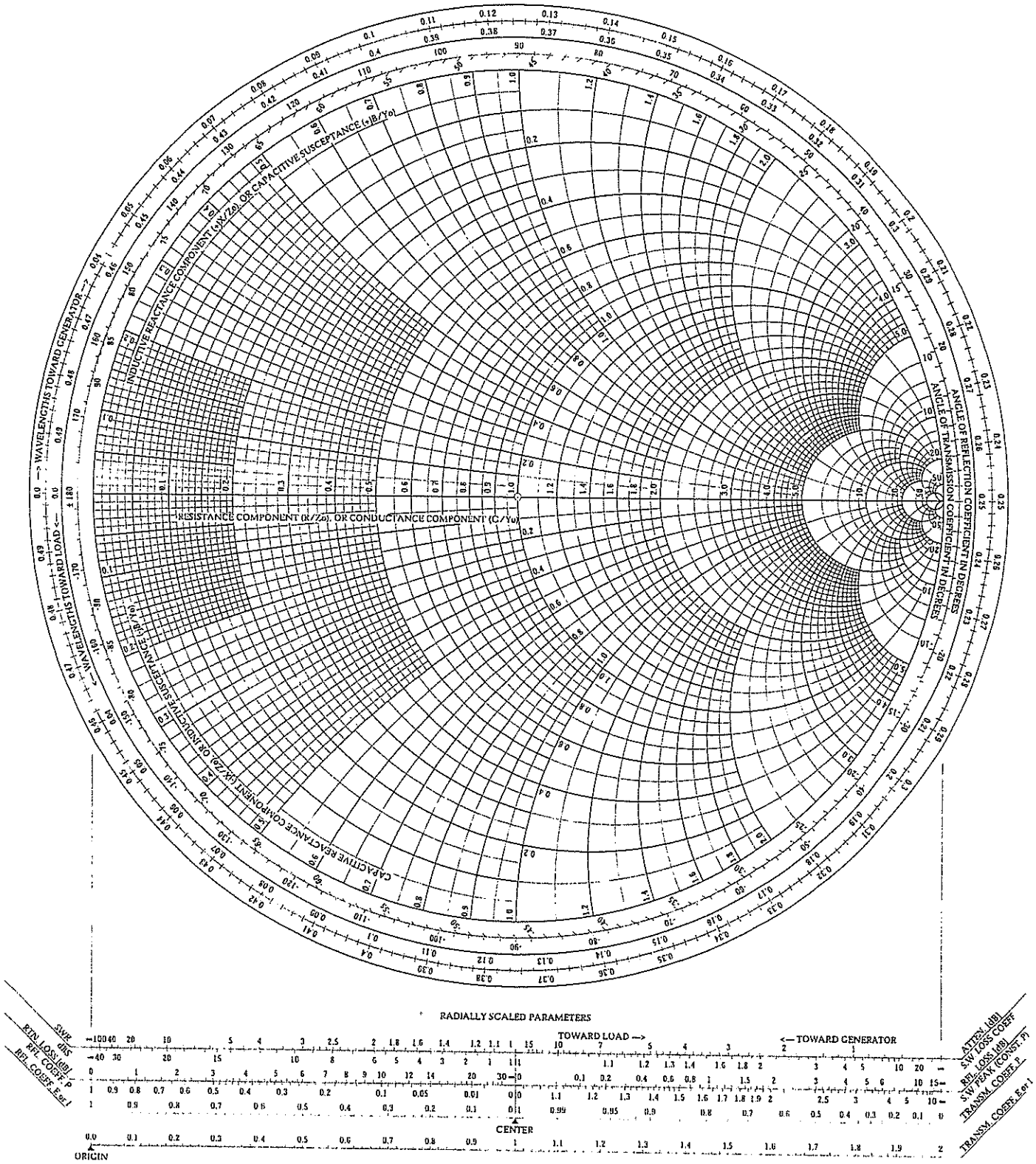

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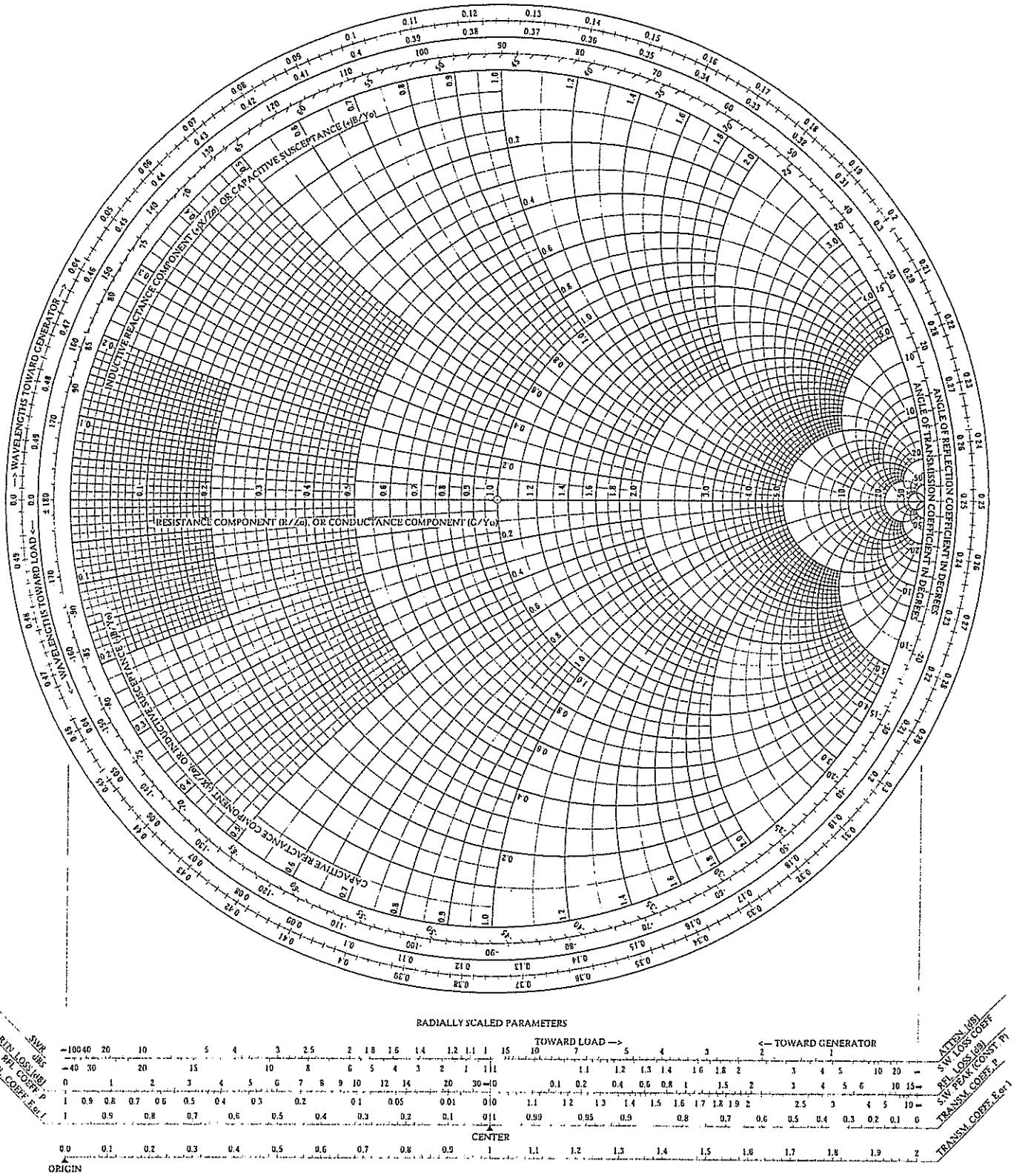

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